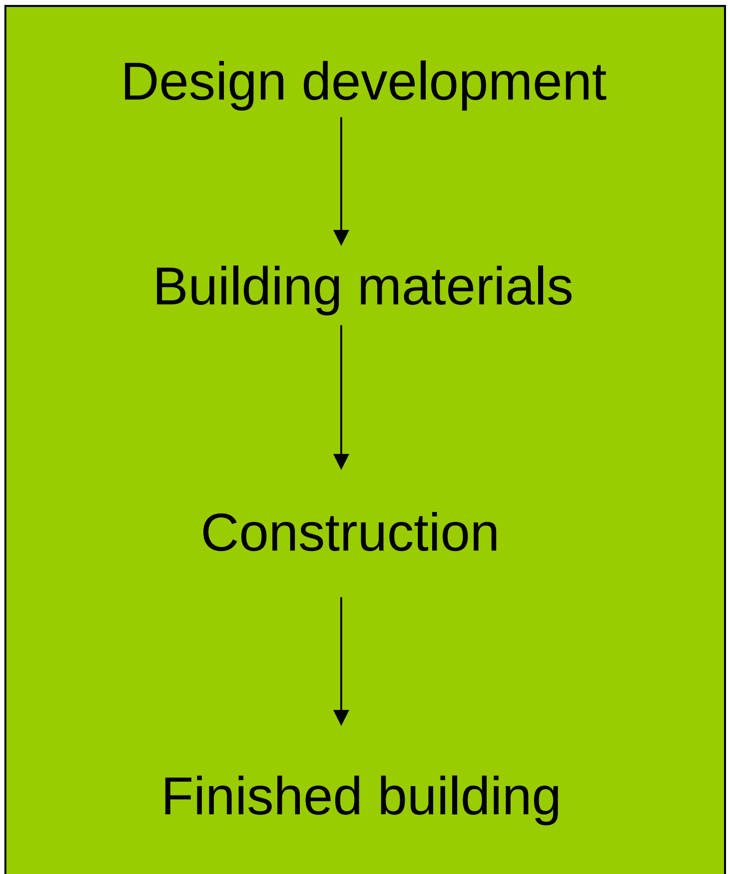
LIFE CYCLE ANALYSIS (LCA)

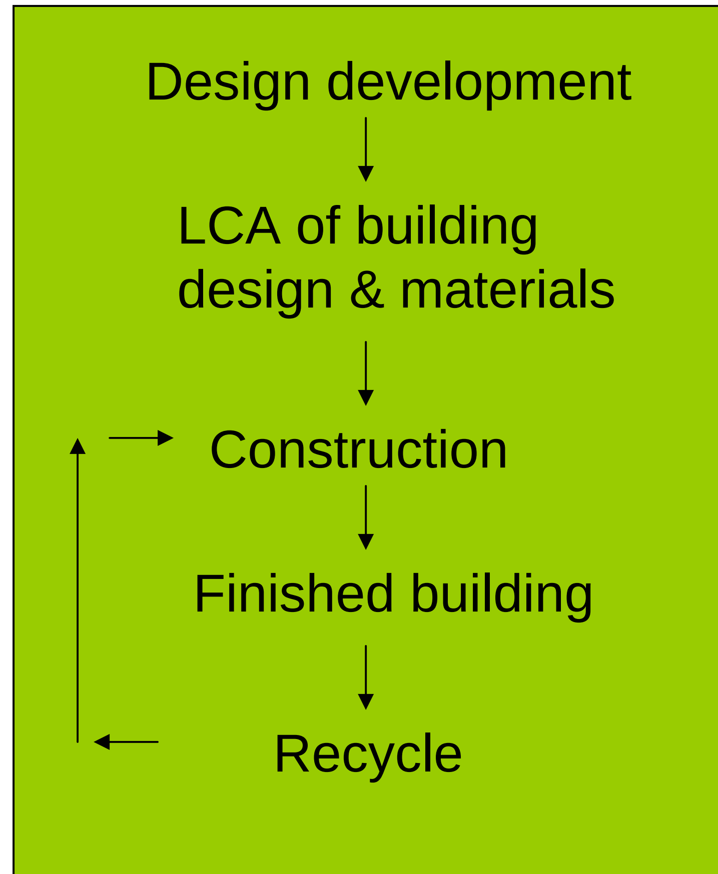
Ar. Sakshi Kulkarni

DESIGN DEVELOPMENT

Conventional approach



Innovative approach



LIFE CYCLE DESIGN APPROACH

DETERMINING FACTORS

- Quality,
- Cost,
- Production feasibility,
- Requirements of use,
- Servicing and
- Environmental aspects.

DEFINITION

- **Life-cycle analysis** (LCA) is a process to

evaluate the environmental burdens associated with a product or process by identifying energy and materials used and waste released throughout it's life cycle

  – Life-Cycle Analysis attempts to measure the "**cradle to grave**" impact on the ecosystem.

USE OF LCA

- In the design process to determine which of several designs may leave **a smaller "footprint on the environment",** or
- To identify environmentally preferred products, **eco-labeling** programs and
- To help government to **develop policies**.

- Also, the study of reference or benchmark LCAs provides insight into the main causes of the environmental impact of a certain kind of product and **design priorities** and **product design guidelines** can be established based on the LCA data.

Difference in usage:

- For designers, the inventory does not need to be exhaustive to be useful.

- For eco-labeling, the inventory should be rigorous, easily verifiable and periodically updated.

HISTORY

- LCAs started in the early 1970s, initially to investigate the energy requirements for different processes.
- Emissions and raw materials were added later.
- LCAs are considered to be the most comprehensive approach to assessing environmental impact.

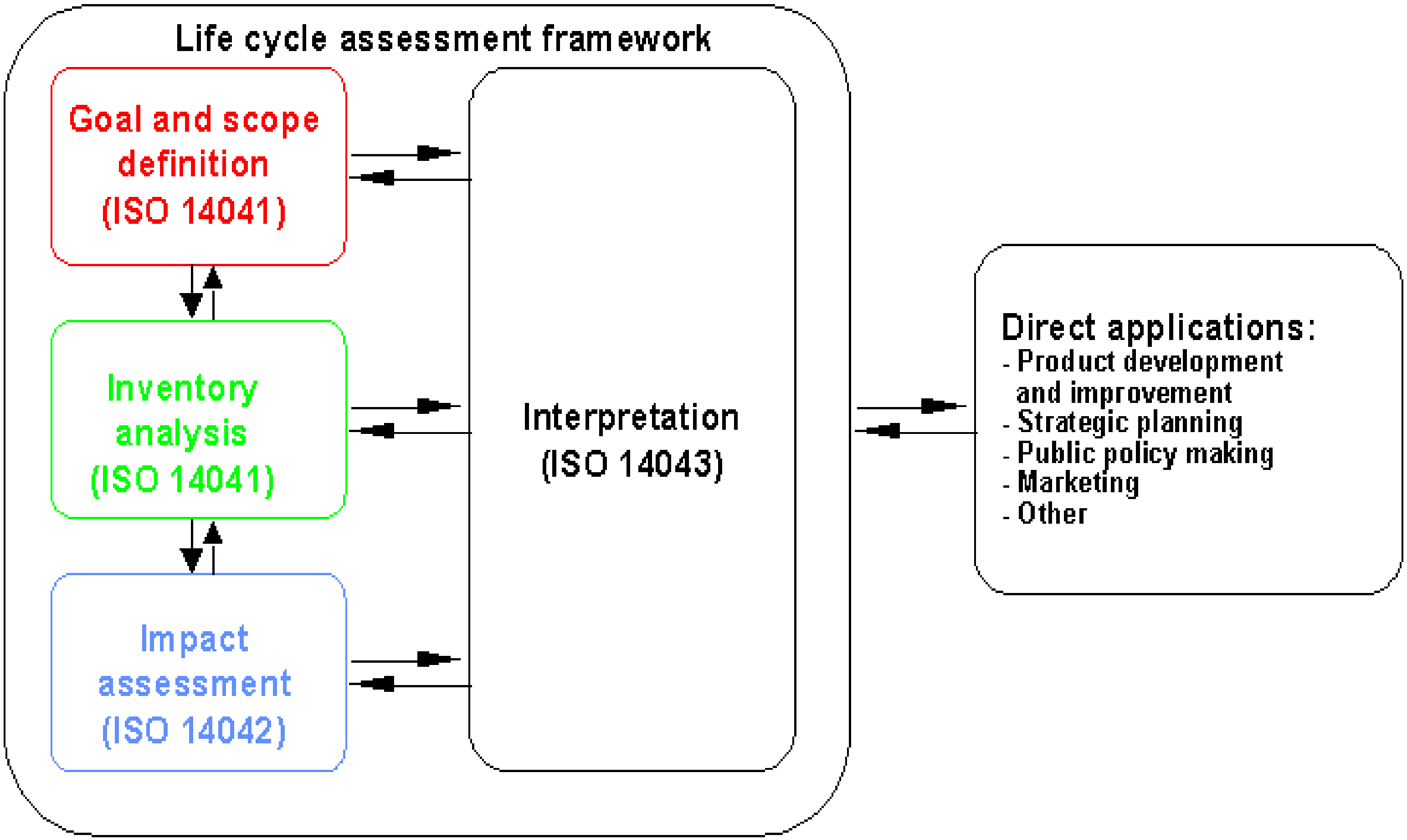
LCA METHODS

- Initially, numerous variants of LCA “methods” were developed/investigated, but today there is consensus that there is only one basic method with a large number of variants

- The Society of Environmental Toxicology and Chemistry (SETAC), an international platform for toxicologists, published a Code of Practice, a widely accepted series of guidelines and definitions (1990).

- IS0 14040-14043 is considered to be frame work for the LCA (1997).

LCA STEPS



Life cycle assessment framework
Goal and scope definition (ISO 14041)
Inventory analysis (ISO 14041)
Impact assessment (ISO 14042)
Interpretation (ISO 14043)
Direct applications:
- Product development and improvement
- Strategic planning
- Public policy making
- Marketing
- Other

LCA STEP - 1

1. Goal definition (ISO 14040)**:**

– **The basis and scope of the evaluation are defined.**

- Issues need to be defined

- Initiator and target group
- The purpose (comparison, ecolabeling, improvements)
- The subject of the study
- The level of detail required

- In addition, the system boundaries - for both **time and place** - should be determined.

LCA STEP-2

2-5. Inventory Analysis (ISO 14041):

2. Construction of process flow chart
3. Collecting the data
4. Defining system boundaries
5. processing the data

LIMITATIONS OF INVENTORY STAGE

- The inventory phase usually takes a great deal of time and effort and mistakes are easily made.
- There exists published data on impacts of different materials such as plastics, aluminum, steel, paper, etc.

  However, the data is often inconsistent and not directly applicable due to different goals and scope.

  -It is expected that both the quantity and quality of data will improve in the future.

LCA STEP - 3

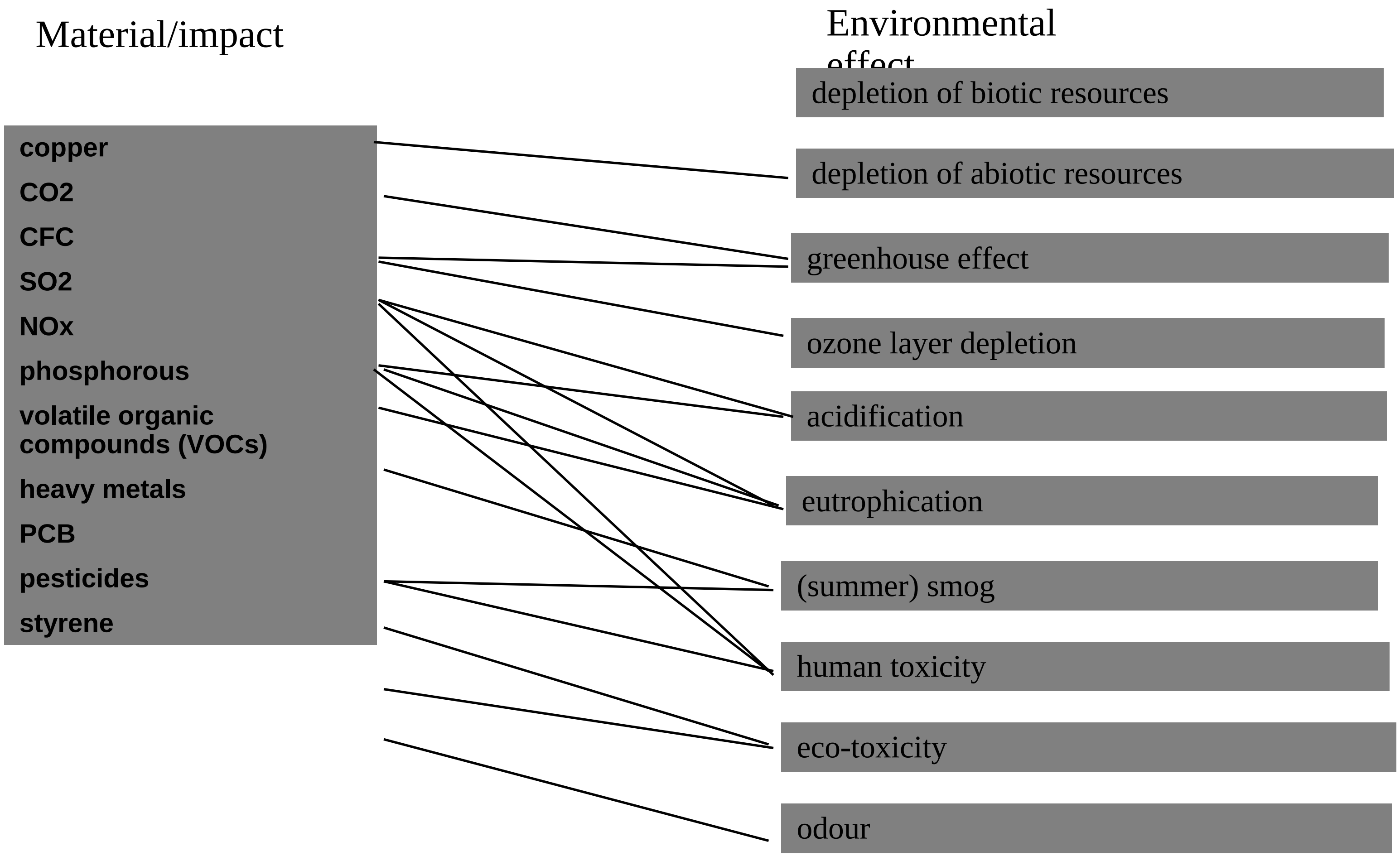
6-7. Impact Assessment (ISO 14042)**:**

6. Classification and characterization
7. Valuation

– Emissions and consumptions are translated into environmental effects.

– The are environmental effects are grouped and weighted.

LCA STEP - 3


Material/impact
Environmental effect
copper
CO2
CFC
SO2
NOx
phosphorous
volatile organic compounds (VOCs)
heavy metals
PCB
pesticides
styrene
depletion of biotic resources
depletion of abiotic resources
greenhouse effect
ozone layer depletion
acidification
eutrophication
(summer) smog
human toxicity
eco-toxicity
odour

LCA STEP - 4

8. Improvement Assessment / Interpretation (ISO 14043)**:**

- The final step in Life-Cycle Analysis is to identify areas for improvement.

- Consult the original goal definition for the purpose of the analysis and the target group.

LCA STEP - 4

- Life-cycle areas/processes/events with large impacts (i.e., high numerical values) are clearly the most obvious candidates

- However, what are the resources required and risk involved?
  - Good areas of improvement are those where large improvements can be made with minimal (corporate) resource expenditure and low risk.

CASE STUDY

INPUT FOR 1T CEMENT PRODUCTION

INPUT

Mixed Limestone	1402.5
Limestone with high CaO	82.5
Limestone with high MgO	82.5
Shale	1.5
Sandstone	49.5
Iron Ore	8.25

ENERGY	AMOUNT (GJ/T)
Thermal	3.0
Electrical	1.21

WATER CONSUMPTION

INPUT

USE	AMOUNT(Lit/T)
Cooling	1703.7
Raw material Washing and beneficiation	109.79
Process	946.5
Dust Control	265020
Dust Leaching	6133.3
Dust Disposal	208.23
Wet scrubber	30666

OUTPUT

MAIN PRODUCT	1T Cement
EMISSIONS TO AIR **A) Manufacturing process**	
Dust particles	0.2 Kg /T
CO2	1000.0 kg/ T
NOx	3.9 Kg/T
SO2	3.7 Kg/T
B) Combustion of fossil fuel (Thermal energy consumption)	
Dust particals	0.015 Kg/T
Hydrocarbons	1.Kg/T
CO2	825.00 kg/T
CO	0.01 Kg/T
NOx	0.071 Kg/T
SO2	0.32 Kg/T
C) Electrical energy consumption	
CO2	1.Kg/T
NOx	0.11 Kg/T
SO2	0.249 Kg/T

OUTPUT

EMISSIONS TO WATER

(pollution parameters)	
Total dissolved Solids	5.95 Kg/T
Total suspended solids	0.81 Kg/T
Alkalinity	1.24 Kg/T
Potassium	2.96 Kg/T
Sulphate	5.99 Kg/T
Aluminum	trace
Iron	trace
Lead	trace
Chromium	trace
Oil & grease	trace
EMISSIONS TO LAND	
Average dry deposition within	
500 meters (depends upon climate	
and wind direction)	0.0000072 Kg/M2/T

Inventory table for 1T of cement production

	Cement production	Electrical energy	Thermal energy	Total
Contribution Factor	1.65	1.21	3.0	
Energy resources	4.21	0.68	0.25	5.14
Emission to Air				
CO_2	1650	84.7	2475	4209.7
CO			0.03	0.03
NO_X	6.435	0.133	0.0138	6.5818
SO_2	6.105	0.3	0.96	7.365
Particles	0.33	0.045	0.045	0.42
Hydrocarbon	0.0138			0.0138

The raw material required for 1T cement production is 1.65 T so the factor for manufacturing process is 1.65.

6. CLASSIFICATION AND CHARACTERIZATION

- Classification specifies which **environmental problems** are to be included in the analysis.

- Characterization is the process by which the impacts of substances considered in the LCA is quantified in terms of the environmental problems considered.

Classification and Characterization table:

	Resource	Emission to air					Total
	GJ	CO_2	NO_X	SO_2	Hydrocarbon	CO	
Inventory Amounts (Kg)	4.21	4209.7	6.5818	7.365	0.0138	0.03	
Equivalency factor							
EDP(GJ)	1.0						
GWP(kg/kg)		1.0					
POPC(kg/kg)					0.377		
AP(kg/kg)			0.7	1.0			
HT(kg/kg)			0.78	1.2		0.012	

Multiplied characterization report

	Resource GJ	Emission to air					Total
		CO2	NOX	SO2	Hydrocarbon	CO	
EDP(GJ)	4.21						4.21
GWP(kg/kg)		4209.7					4209.7
POPC(kg/kg)					0.0052		0.0052
AP(kg/kg)			4.6	7.365			11.965
HT(kg/kg)			5.13	8.838		0.00036	13.96836

GRAPHICAL REPRESENTATION:

- For graphical representation the scores for each environmental problem are normalized.
- In this way it is possible to relate the environmental impacts of the cement production to global emissions and extractions.

Normalization of score

Environmental problems	Score	Unit	Normalized score a.10^{-12}
Energy depletion (EDP)	4.21	GJ	17.9
Global warming potential(GWP)	4209.7	Kg	111.66
Photochemical oxidation formulation(POPC)	0.0052	Kg	1.39
Acidification(AP)	11.965	Kg	41.83
Human toxicity (HT)	13.96836	Kg	24.2

It is done by dividing the score for global warming potential by the annual rate of global warming.

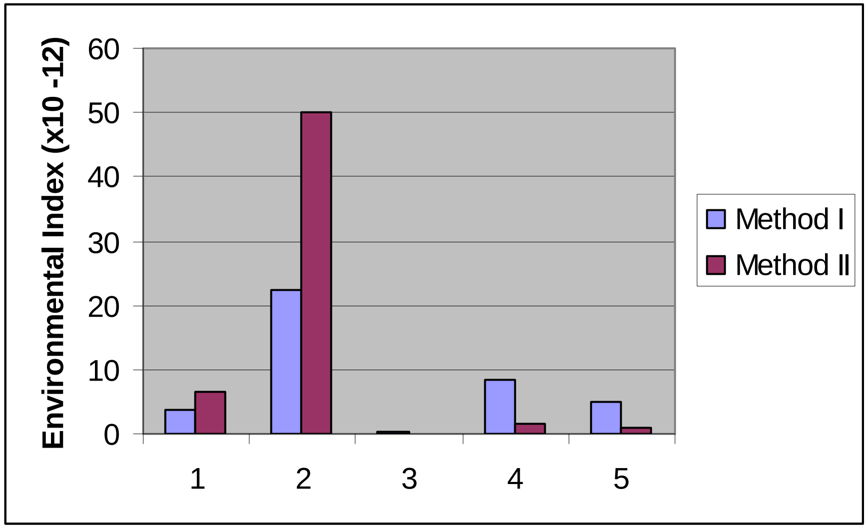
Valuation

- In this step of valuation the results of environmental profile are converted into one index

Environmental problems	Method I	Method II
Energy depletion (EDP)	1/5	0.361
Global warming potential(GWP)	1/5	0.448
Photochemical oxidation formulation(POPC)	1/5	0.113
Acidification(AP)	1/5	0.039
Human toxicity (HT)	1/5	0.039
Total	1	1

Graphical presentation

The environmental index shows that CO_2 emission is the factor that increase the environmental burden due to cement production.



The effects of weighting on the environmental index

SUMMARY

- It is not the product, but the life-cycle of the product that determines its environmental impact.
- The LCA is generally a compromise between practicality and completeness
- LCA is time consuming and costly.
- Data availability is very important.
- Time factor consideration is must.

BEES (Building for Environmental and Economic Sustainability) 3.0 software

Developed by **National Institute of Standards and Technology**

uses the standardized life-cycle assessment approach

Up to 10 environmental impacts are measured across these life-cycle stages.

The software includes about 200 building products with 80 brand-specific products

BEES software

- BEES measures **economic performance** using the **ASTM standard** life-cycle cost method.
- covers the **costs of initial investment, replacement, operation, maintenance and repair, and disposal.**
- The life-cycle cost method sums these costs over a fixed period of time, known as the study period.
- Alternative products for the same function, can then be compared on the basis of their lifecycle costs to determine which is the least-cost means over the study period.

-Thank you